

# The Phase 2 upgrade of CMS Drift Tube Detector for High Luminosity LHC

Archana Sharma on behalf of the CMS Muon group

III. Phy. Institute A, RWTH Aachen

Email : [archie.sharma@cern.ch](mailto:archie.sharma@cern.ch)



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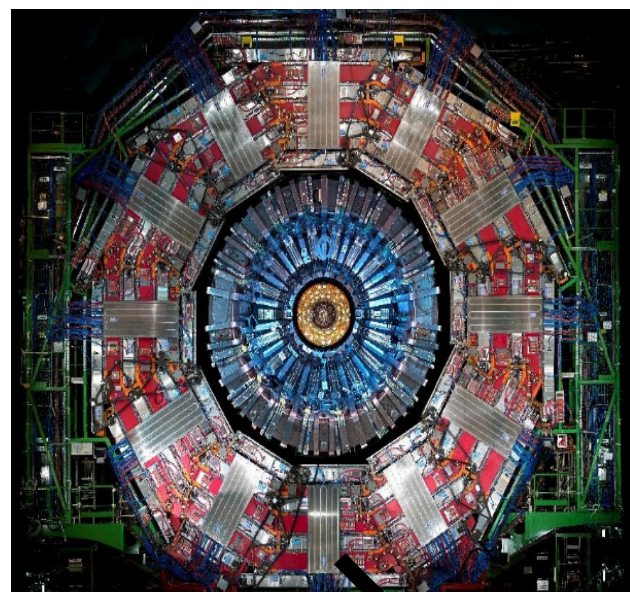


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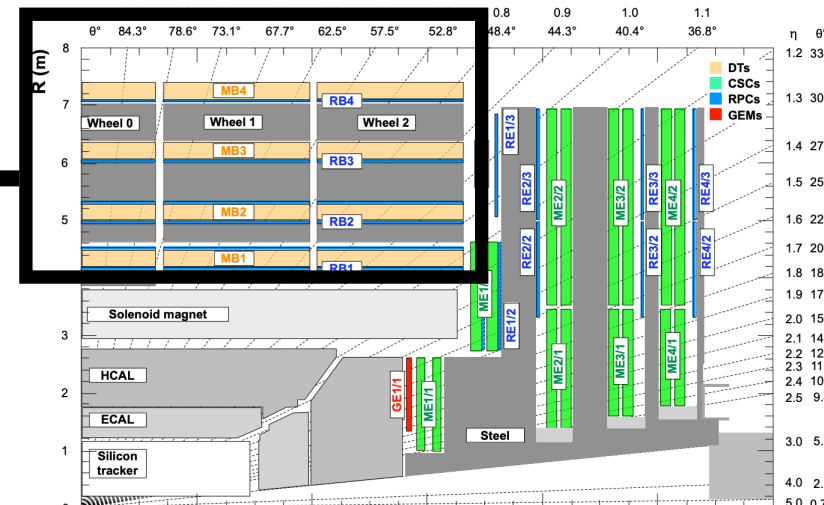
## Overview

### Drift Tubes (DT)

- 5 wheels in the CMS barrel (YB[-2,-1,0,+1,+2])
- 4 concentric rings of stations (MB 1-4)
- 12 sector slices (Sec 1-12)

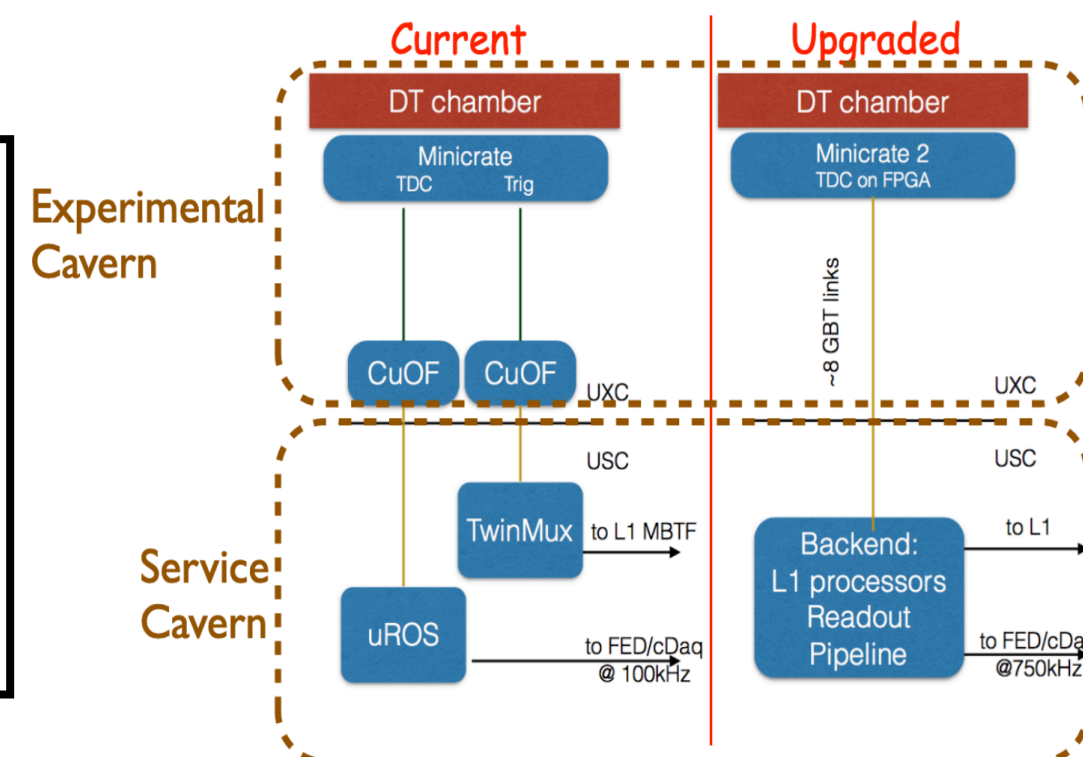


### CMS Muon System

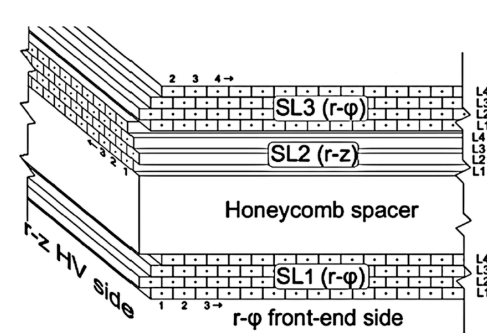
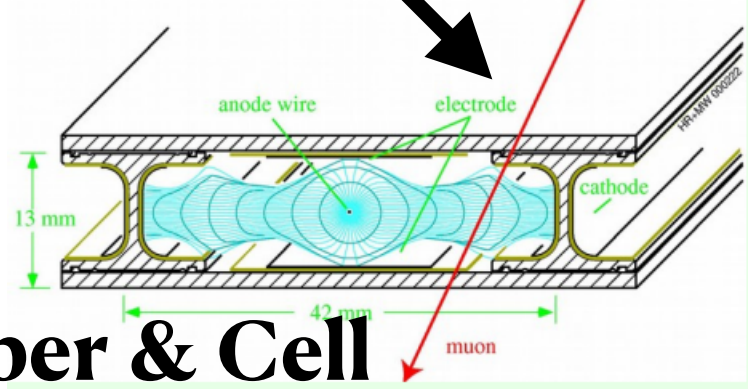


### Challenges @ high luminosity LHC

- Increase in CMS maximal Level-1 Trigger (L1T) rate
- Trigger latency from 3.6  $\mu$ s to 12.5  $\mu$ s
- Chambers/electronics to be operated at high radiation background



### DT Chamber & Cell



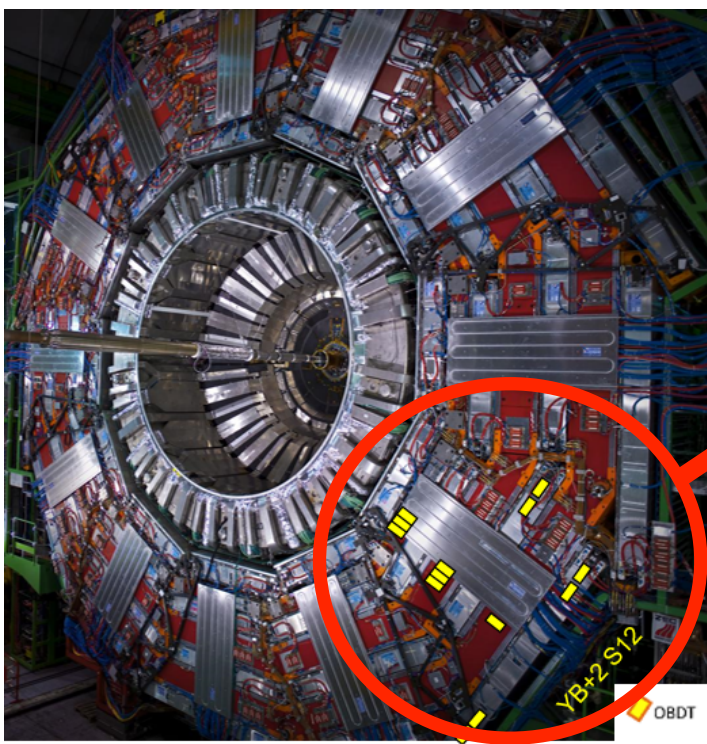
- Wire resolution  $\sim 250 \mu$ m
- Local reconstruction (r- $\phi$ )  $\sim 100 \mu$ m
- Efficiency  $\sim 99\%$

### DT Upgrade motivation

- Higher acceptable L1 trigger rate
- Reduced HW complexity and more granularity
- More convenient maintenance

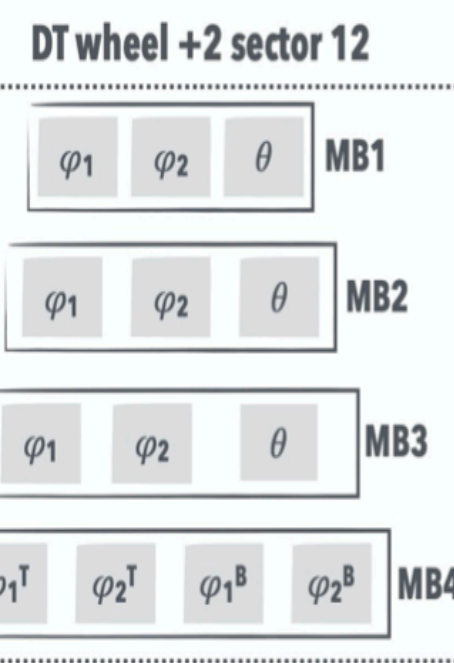
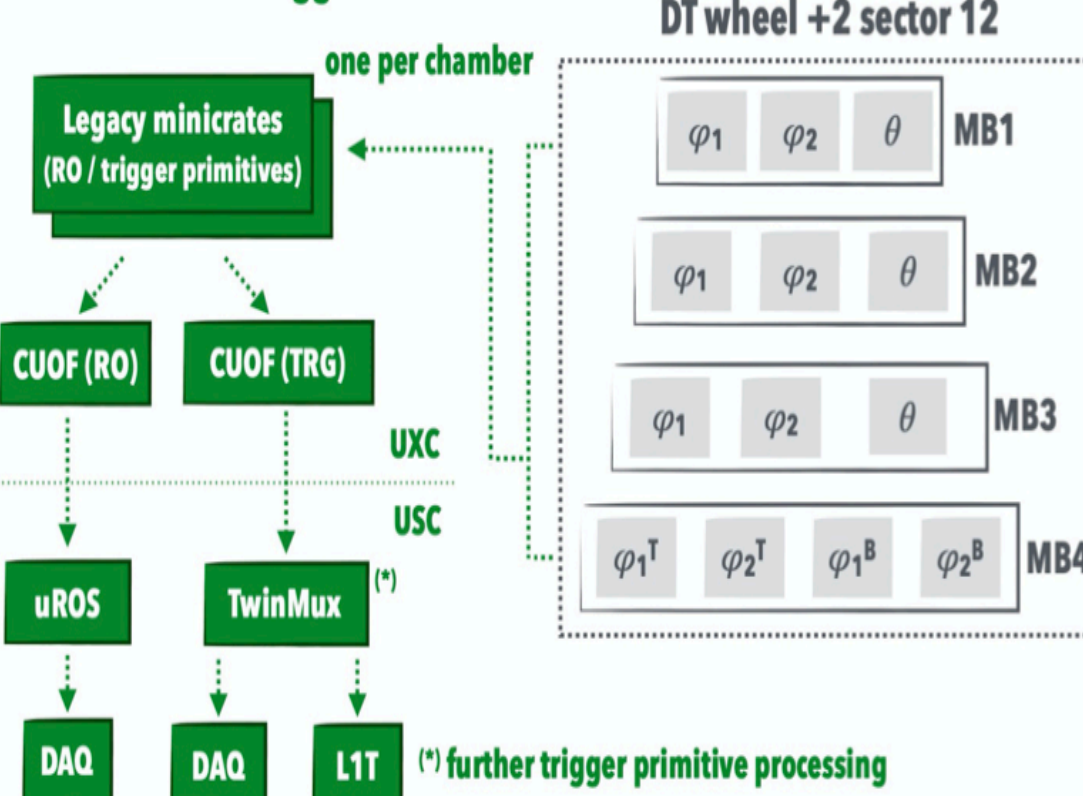
## Phase 2 DT Slice Test

Four DT chambers in Sec 12 of wheel YB+2 have been equipped with Phase 2 On Boards DT electronics (OBDT) : **DT Slice Test**

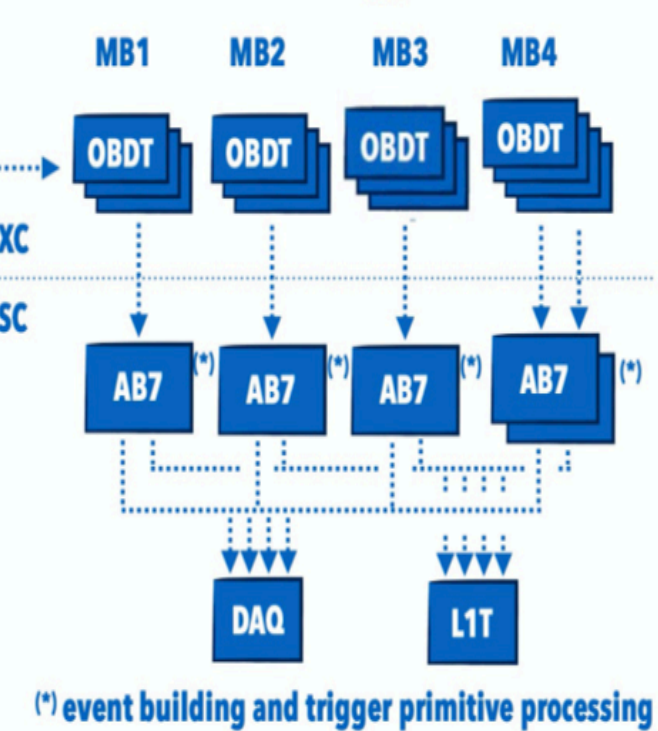


OBDT prototype v1.0

### Phase-1 DT RO/trigger chain



### Slice Test RO/trigger chain



- DT Phase 2 Slice Test chain working in parallel with legacy
- The FE (front end) signal splitters, split the signal from the chamber and route it to both legacy and Phase 2

## Phase 2 DT Slice Test Performance

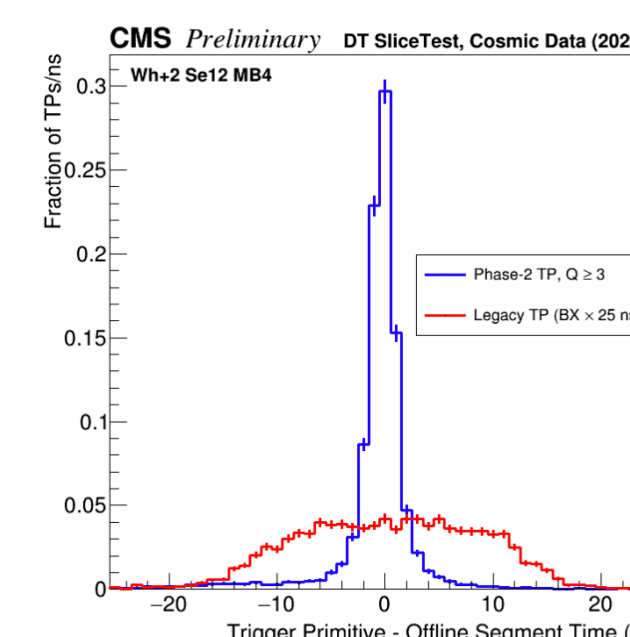
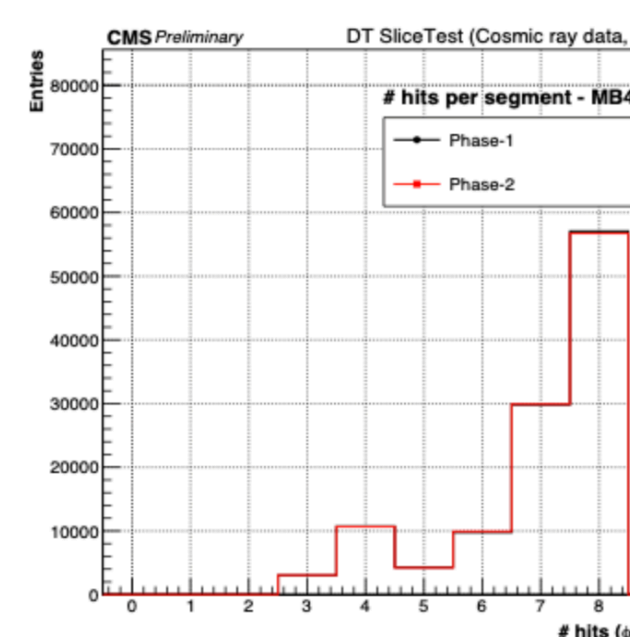
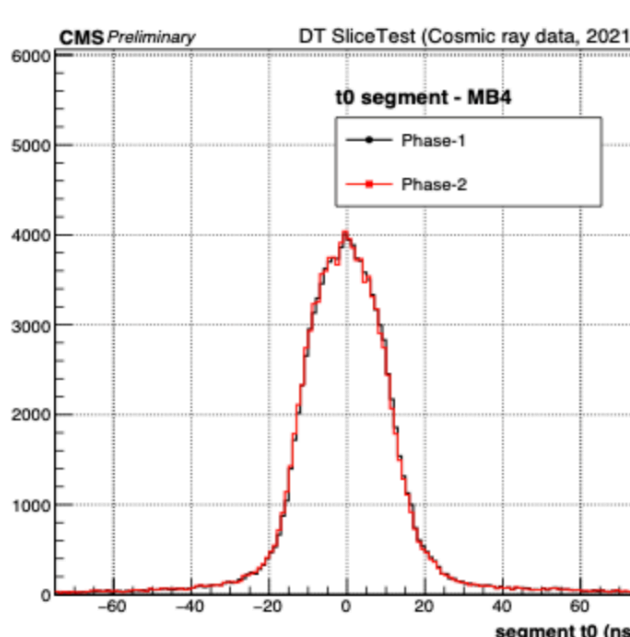
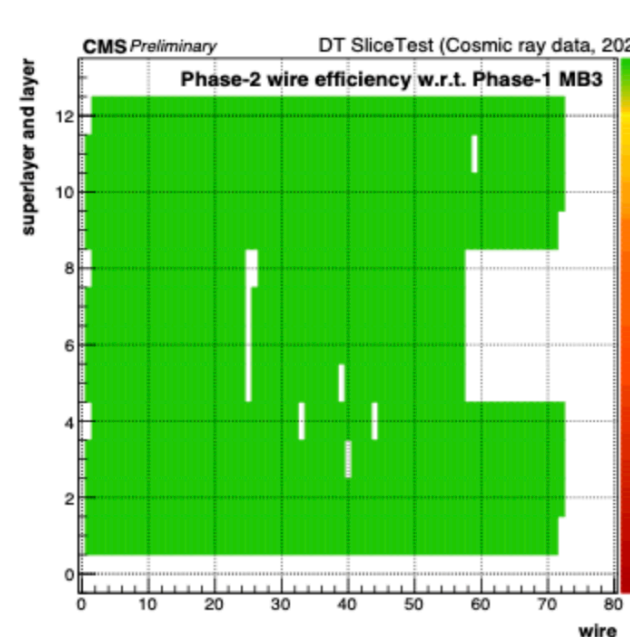
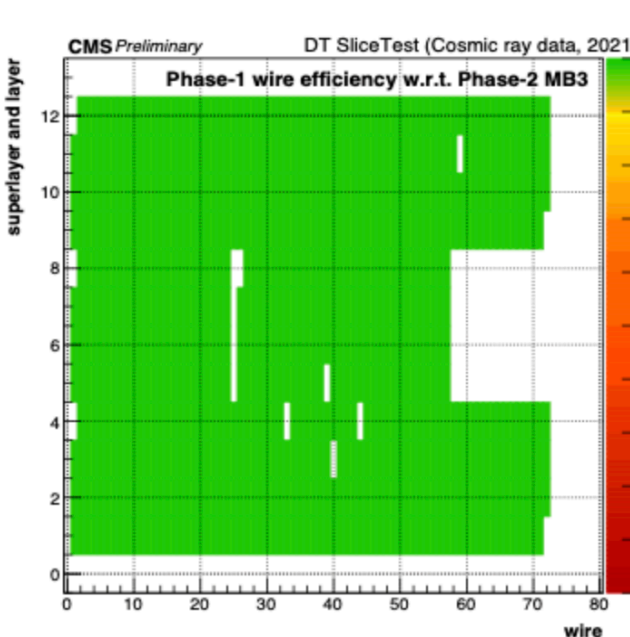
Relative efficiency to detect a hit with Phase 1 readout, when a hit is recorded by the Phase 2 readout (**left**) and vice versa (**right**).

- Very good agreement between the Phase 1 and Phase 2 performance is observed

Crossing time (**left**) and number of associated hits (**right**) of segments reconstructed using Phase 1 (black) and Phase 2 (red) digis.

- Remarkable agreement is observed between Phase 1 and Phase 2

Difference between trigger primitive's (TP) time and the offline reconstructed segment time, for Phase 2 (in blue) and for legacy trigger (in red)



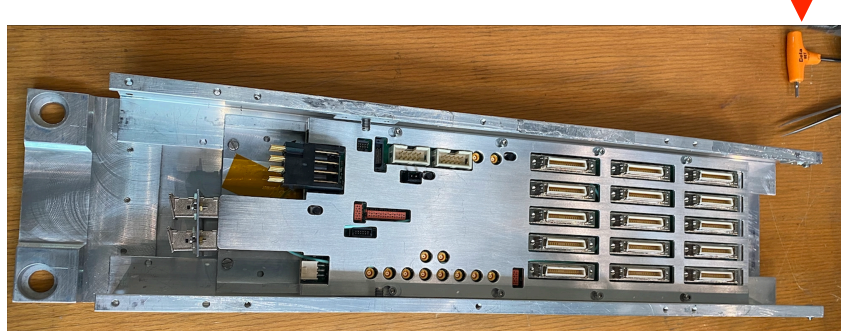
Due to the better time granularity, improved time resolution in Phase 2 for the cosmic muons, as the lower fraction of triggers at the wrong BX (12.5 ns away from the time the muon crossed the chamber)

## Hardware developments of DT Phase 2 Upgrade

### $\phi$ -OBDT v2



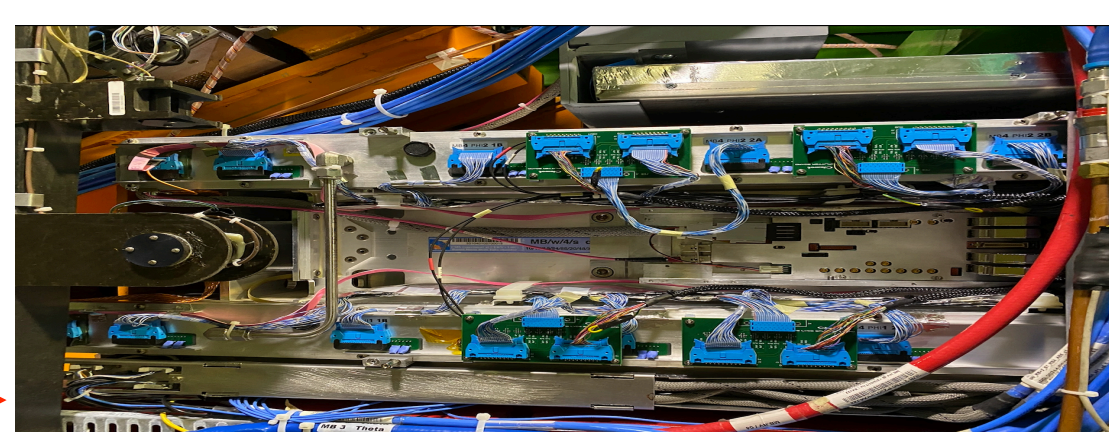
On mechanical support



On DT Chamber

Pre-production of few  $\phi$ -OBDT v2 (new safety features & revised clock distribution) prototypes for DT  $\phi$ -superlayers

- One  $\phi$ -OBDT v2 prototype already installed in one DT chamber, commissioning ongoing



### OBDT Theta



5 OBDT theta prototypes assembled with the IpGBTs are produced and validation ongoing in the lab

- Work also ongoing on the mechanical integration and routing of the fibres

### Summary

- The Phase 2 DT Slice Test successfully installed & operated over LHC LS2
- The performance is in line with the Phase 1 system already exploiting the DT cell resolution
- Aiming to operate the present DT Phase 2 Slice Test during Run 3 in parallel to the legacy system
- Further developments of OBDT prototype versions are ongoing in parallel